Computational Structural Mechanics and Dynamics
Practice 1

Anil Bettadahalli Channakeshava,Rupalee Deepak Baldota

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1 Introduction:

In this report we are analysing different types of 2D problems considering the problem type as plane state and the behaviour of displacement and stresses are analysed with different types of elements and different size of mesh elements and are compared.

Exercise 1: Thin plate under dead weight:

We have analyzed the given problem using different noded elements like: Triangular elements with 3 and 6 nodes and Quadrilaterals with 4, 8 and 9 nodes as suggested in the problem.And obtained the result by refining mesh element size of 0.1 for different elements using the given material and boundary conditions.The displacement and stress distribution for different elements is shown below.

(1) 3-noded triangular elements

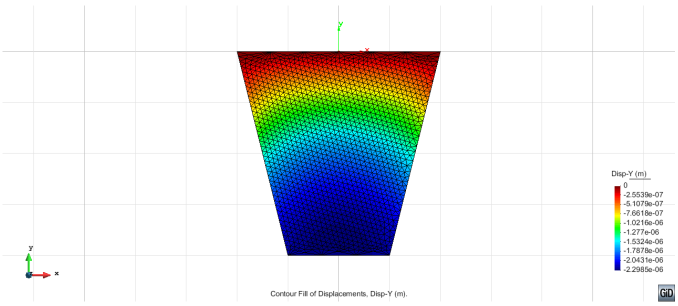

Figure 1: 3-noded Triangular mesh displacement

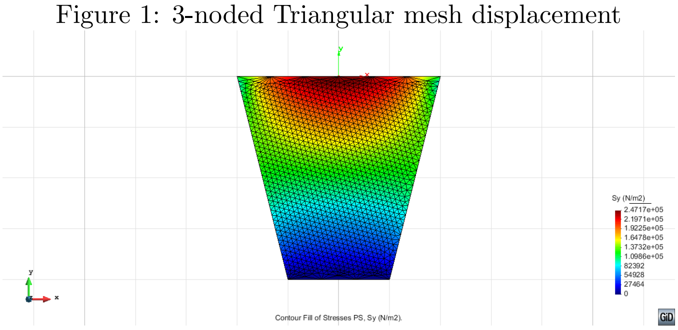

Figure 2: 3-noded Triangular mesh stress

(2) 6-noded triangular elements

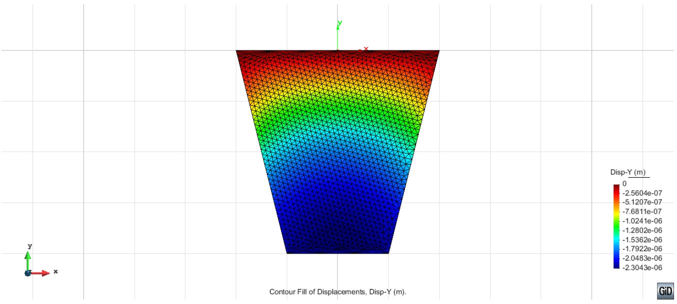

Figure 3: 6-noded Triangular mesh displacement

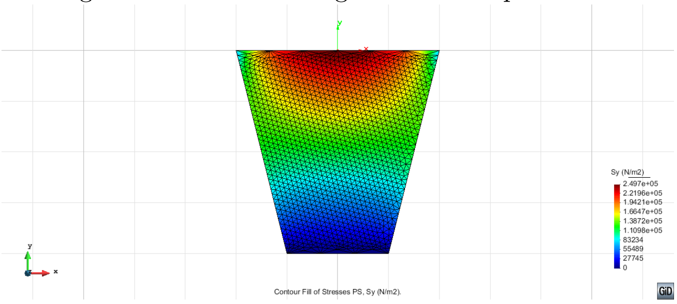

Figure 4: 6-noded Triangular mesh stress

(3) 4-noded quadrilateral elements

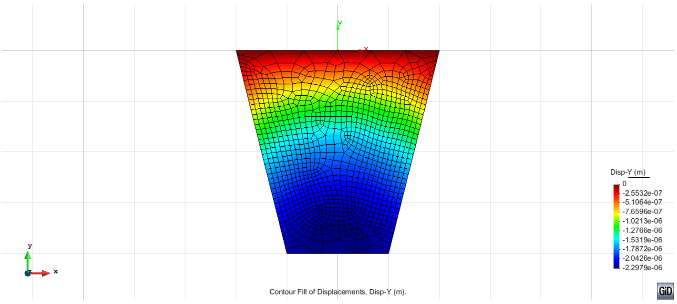

Figure 5: 4-noded Quadrilateral mesh displacement

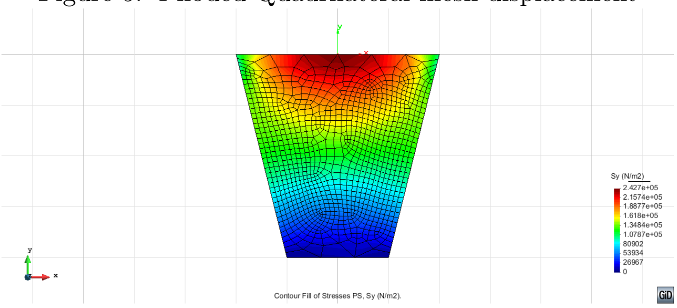

Figure 6: 4-noded Quadrilateral mesh stress

(4) 8-noded quadrilateral elements

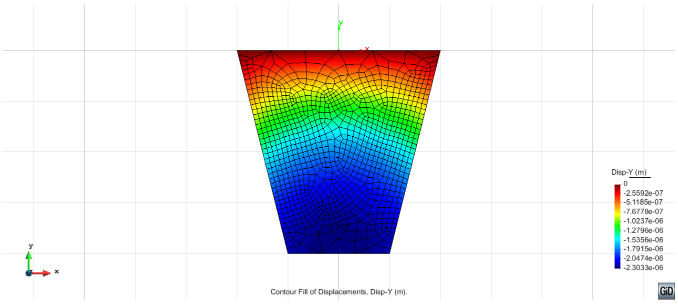

Figure 7: 8-noded Quadrilateral mesh displacement

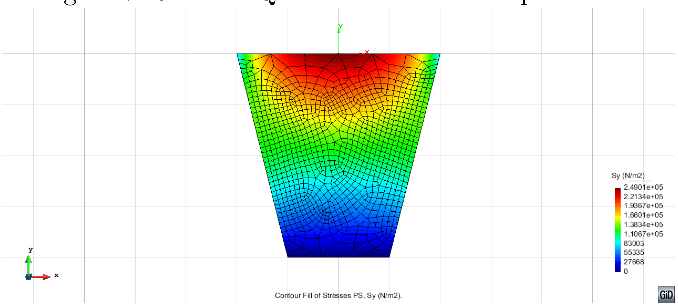

Figure 8: 8-noded Quadrilateral mesh stress

(5) 9-noded quadrilateral elements

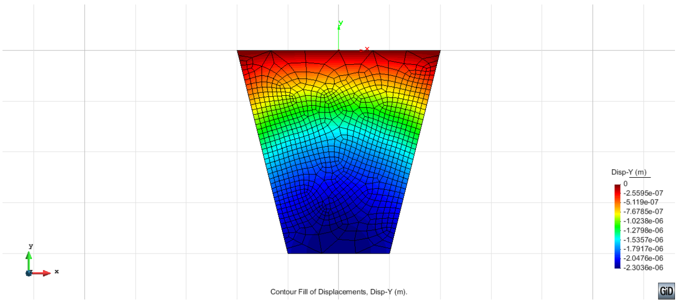

Figure 9: 9-noded Quadrilateral mesh displacement

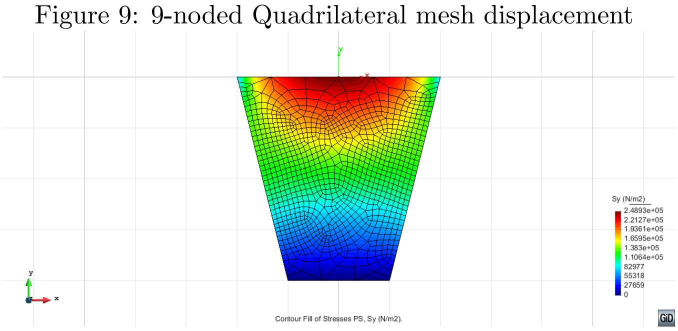

Figure 10: 9-noded Quadrilateral mesh stress

From the data of the problem it is given that sought solution :Center of side ED Displ - Y=$2.26e^{-}6m$ and $PointB, \sigma_y = 0.247\frac{MN}{m^2}$.From the above simulated images for different elements and from comparison table below, we can see that solution obtained from 3-noded triangular element converges to the solution(displacement and stress) given in the problem compared to other elements.

Comparison		
Element Type	Center of side ED Displ -Max.Y(m)	Point B ,$Max.\sigma_y$ ($\frac{MN}{m^2}$)
3-noded triangular	$2.2985e^{-6}$	0.24717
6-noded triangular	$2.3043e^{-6}$	0.2497
4-noded quadrilateral	$2.2979e^{-6}$	0.2427
8-noded quadrilateral	$2.3033e^{-6}$	0.24901
9-noded quadrilateral	$2.3036e^{-6}$	0.24893

Exercise 2: Plate with two sections:

We have analyzed the given problem using triangular elements with 3 nodes with and given material , boundary conditions,load and obtained the stress distribution.Compared the stress distribution for mesh element size (1) and refined mesh element size (0.1).After refining mesh the result obtained was more accurate and the comparison between stress distribution for different mesh size is shown below.

(1) 3-noded triangular elements with mesh element size (1)

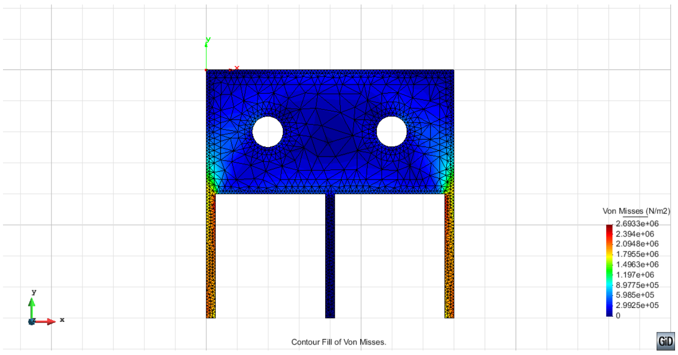

Figure 11: Von Mises Stress distribution

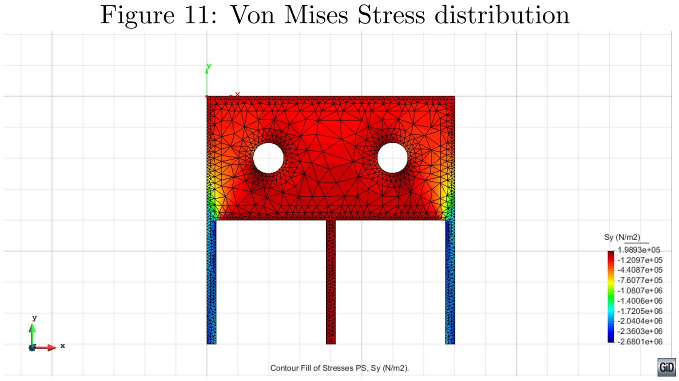

Figure 12: Stress distribution along y

(2) 3-noded triangular elements with refined mesh element size (0.1)

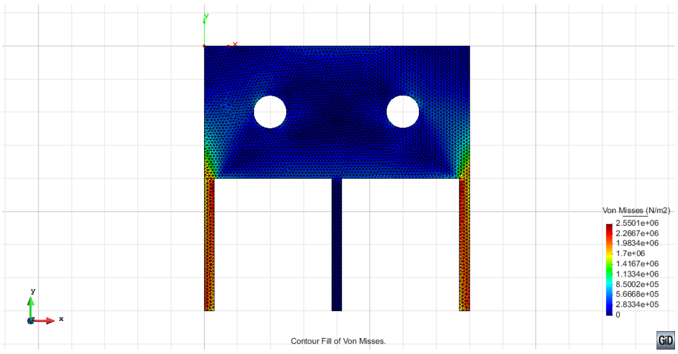

Figure 13: Von Mises Stress distribution

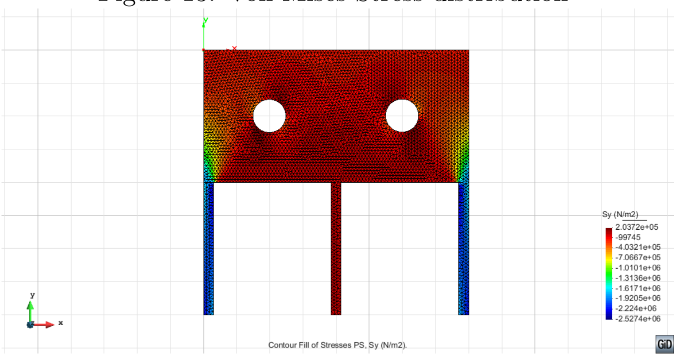

Figure 14: Stress distribution along y

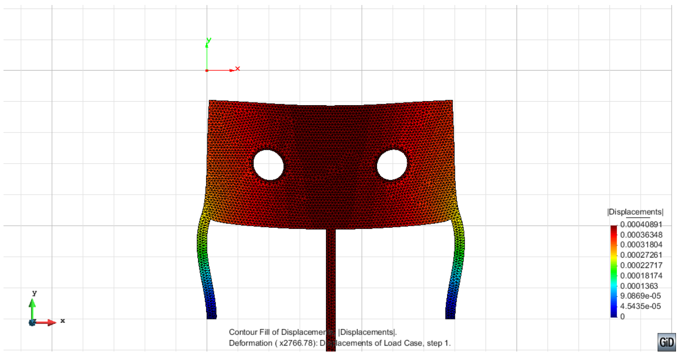

Figure 15: Displacements

From the above simulations we can see that with mesh element size (1), the Max. Von Mises stress is obtained as $2.6933e^{+6}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 1.9893e^{+5}\frac{N}{m^2}$.The value of Max.stress along x and Max.Shear stress is obtained as $\sigma_x = 6.557e^{+5}\frac{N}{m^2}$ and $T_{xy} = 3.096e^{+5}\frac{N}{m^2}$. After refining mesh element to size of (0.1), the Max. Von Mises stress is obtained as $2.5501e^{+6}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 2.0372e^{+5}\frac{N}{m^2}$ which is more accurate.The value of Max.stress along x and Max.Shear stress is obtained as $\sigma_x = 7.8603e^{+5}\frac{N}{m^2}$ and $T_{xy} = 3.7852e^{+5}\frac{N}{m^2}$.

From the simulation it can be seen that Max.Von Mises stress is maximum at the 2 side columns,which means failure chances are more at that part under the given load. A picture of displacement(deformation) under the given load is also shown in figure 15.

Exercise 3: Plate with ventilation hole:

We have analyzed the given problem using quadrilateral elements with 4 nodes with and given material , boundary conditions,load and obtained the stress distribution in the plate and the metal reinforcement sheets.Compared the stress distribution for mesh element size (0.1) and refined mesh element size (0.05).After refining mesh the result obtained was more accurate and the comparison between stress distribution for different mesh size is shown below.

(1) 4-noded quadrilateral elements with mesh element size (0.1)

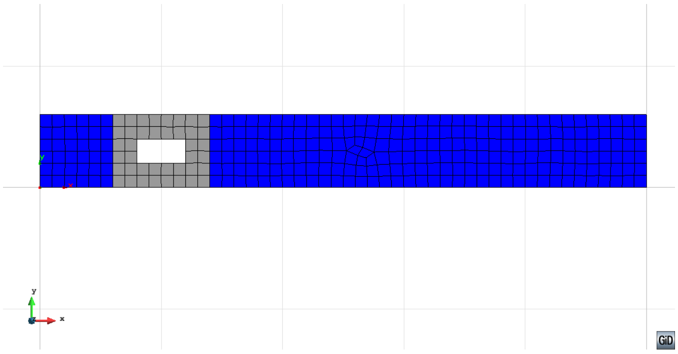

Figure 16: Meshing

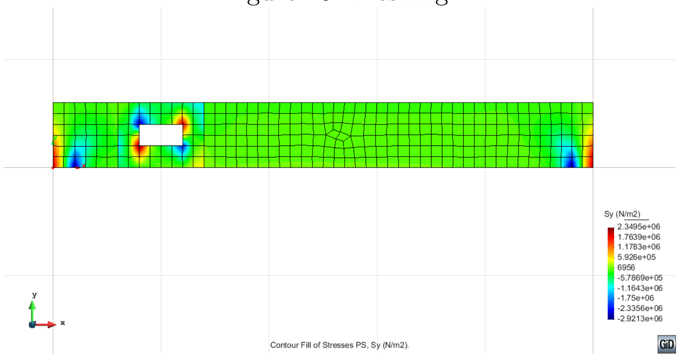

Figure 17: Stress distribution along y

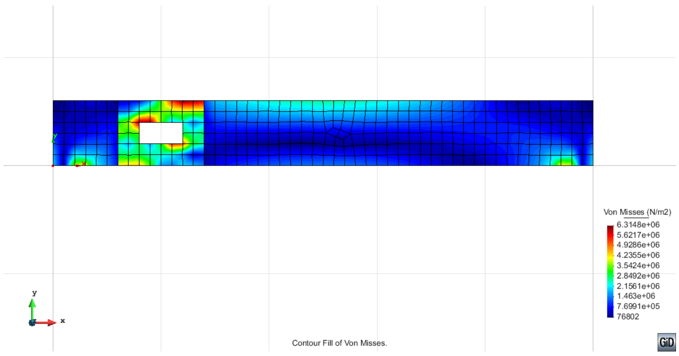

Figure 18: Von Mises Stress distribution

(2) 4-noded quadrilateral elements with refined mesh element size (0.05)

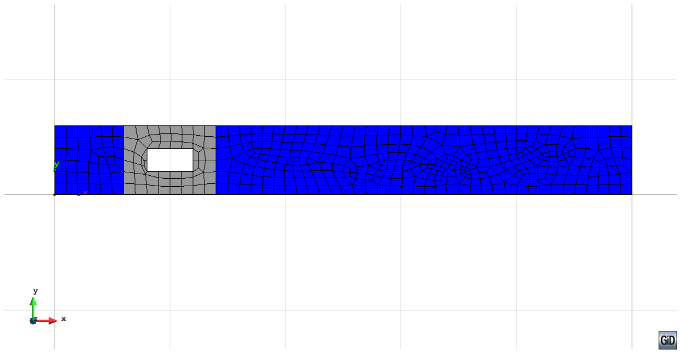

Figure 19: Meshing

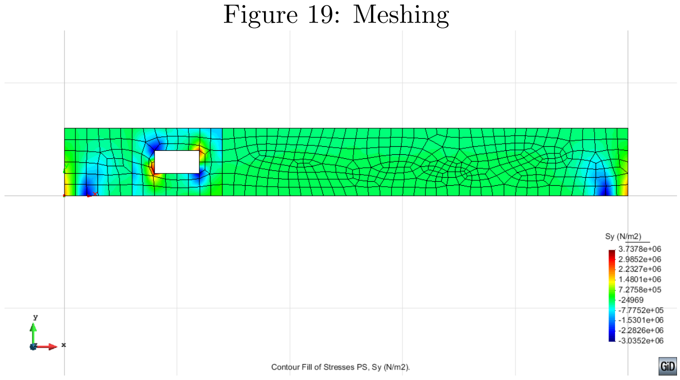

Figure 20: Stress distribution along y

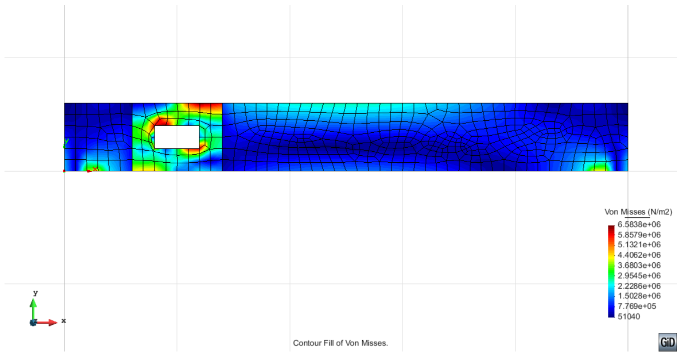

Figure 21: Von Mises Stress distribution

From the above simulations we can see that with mesh element size (0.1), the Max.Von Mises stress is obtained as $6.3148e^{+6}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 2.3495e^{+6}\frac{N}{m^2}$.The value of Max.stress along x and Max.Shear stress is obtained as $\sigma_x = 1.9958e^{+6}\frac{N}{m^2}$ and $T_{xy} = 1.4893e^{+6}\frac{N}{m^2}$. After refining mesh elements to size of (0.05), the Max.Von Mises stress is obtained as $6.5838e^{+6}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 3.7378e^{+6}\frac{N}{m^2}$ which is more accurate.The value of Max.stress along x and Max.Shear stress is obtained as $\sigma_x = 2.6856e^{+6}\frac{N}{m^2}$ and $T_{xy} = 1.6209e^{+6}\frac{N}{m^2}$.

From the simulation it can be seen that Max.Von Mises stress is maximum at the metal reinforcement sheets,which means failure chances are more at that part under the given load than reinforced concrete plate.Since yield strength of steel is more than concrete,it can withstand more load than instant breakage/cracks as in case of concrete.Hence the placement of a metal reinforcement sheet on both sides of the plate in the area of the hole is a good design.

Exercise 4: Prismatic water tank:

We have analyzed the given problem using quadrilateral elements with 4 nodes with and given material , boundary conditions,load (water pressure,$p = \rho g h$),considered the base slab to be elastically supported by the ground and obtained the stress distribution of the cross-section of the tank.Compared the stress distribution for mesh element size (0.1) and refined mesh element size (0.05).After refining mesh the result obtained was more accurate and the comparison between stress distribution for different mesh size is shown below.

(1) 4-noded quadrilateral elements with mesh element size (0.1)

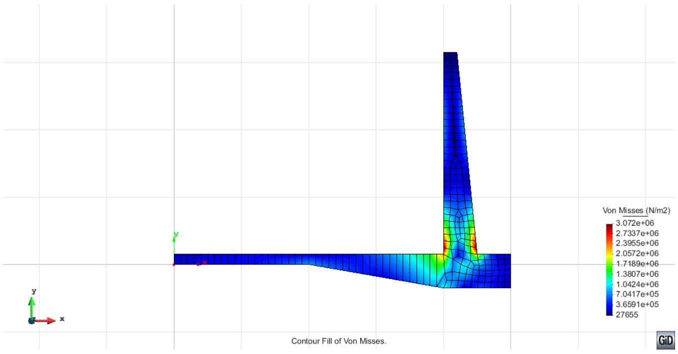

Figure 22: Von Mises Stress distribution

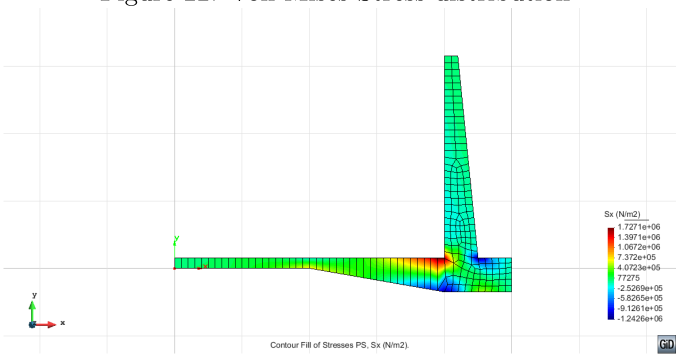

Figure 23: Stress distribution along x

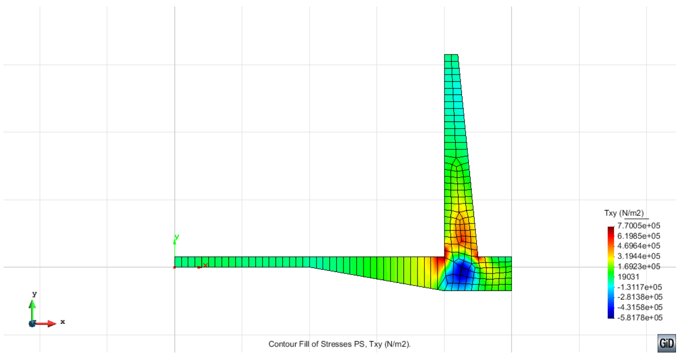

Figure 24: Shear Stress distribution

(2) 4-noded quadrilateral elements with refined mesh element size (0.05)

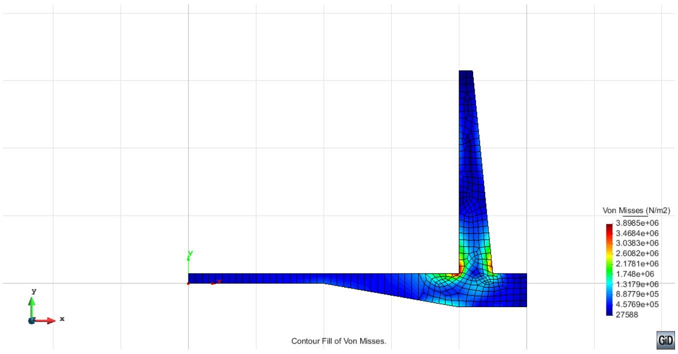

Figure 25: Von Mises Stress distribution

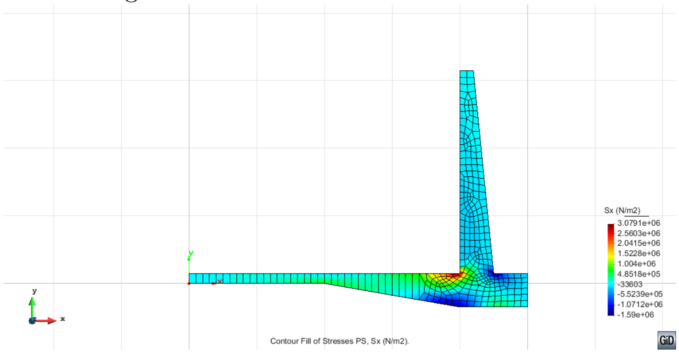

Figure 26: Stress distribution along x

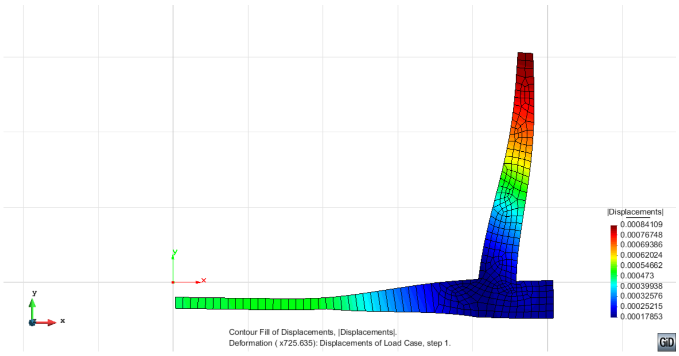

Figure 27: Displacements

From the above simulations we can see that with mesh element size (0.1), the Max.Von Mises stress is obtained as $3.072e^{+6}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 3.0437e^{+6}\frac{N}{m^2}$.The value of Max.stress along x and Max.Shear stress is obtained as $\sigma_x = 1.7271e^{+6}\frac{N}{m^2}$ and $T_{xy} = 7.7005e^{+5}\frac{N}{m^2}$. After refining mesh element to size of (0.05), the Max.Von Mises stress is obtained as $3.8985e^{+6}\frac{N}{m^2}$ and Max.Stress along y is $\sigma_y = 3.6281e^{+6}\frac{N}{m^2}$ which is more accurate.The value of Max.stress along x and Max.Shear stress is obtained as $\sigma_x = 3.0791e^{+6}\frac{N}{m^2}$ and $T_{xy} = 1.3446e^{+6}\frac{N}{m^2}$.

From the simulation it can be seen that Max.Von Mises stress is maximum at the inside corner and outside corner of the tank as the maximum pressure of water is accumulated there.Hence there may be cracks or fracture on concrete at this points for higher pressure of water which results in failure of tank.A picture of displacement(deformation) under the given load is also shown in figure 27.